Importation of Fresh Common Fig (*Ficus carica* L.) Fruit from Mexico into the Continental United States

A Qualitative, Pathway-Initiated Risk Assessment

September 24, 2001

United States Department of Agriculture
Animal and Plant Health Inspection Service
Plant Protection and Quarantine
Commodity Risk Assessment Staff
4700 River Road, Unit 133
Riverdale, MD 20737–1236

CONTENTS

A. Introduction

This pest risk assessment was prepared by the Animal and Plant Health Inspection Service (APHIS) of the United States Department of Agriculture to examine plant pest risks associated with the importation into the continental United States of fresh common fig fruit, *Ficus carica* from Mexico. This qualitative pest risk assessment estimates risk using qualitative terms such as "high" and "low" rather than probabilities or frequencies. The details of the methodology and rating criteria can be found in *Pathway-Initiated Pest Risk Assessments: Guidelines for Qualitative Assessments, Version 5.0* (USDA, 2000) or at *http://www.aphis.usda.gov/ppq/pra/commodity/*.

Regional and international plant protection organizations—e.g., the North American Plant Protection Organization (NAPPO) and the International Plant Protection Convention (IPPC) administered by the Food and Agriculture Organization (FAO) of the United Nations—provide guidance for conducting pest risk analyses. The methods used to initiate, conduct, and report this RA are consistent with guidelines provided by these organizations. Biological and phytosanitary terms conform to the *NAPPO Compendium of Phytosanitary Terms* (Hopper, 1996) and the "Definitions and Abbreviations" (Introduction Section) of *International Standards for Phytosanitary Measures, Section 1—Import Regulations: Guidelines for Pest Risk Analysis* (FAO, 1996) and the *Glossary of Phytosanitary Terms* (FAO, 1999).

B. Risk Assessment

Pest risk assessment is a component of an overall pest risk analysis. The *Guidelines for Pest Risk Analysis* provided by FAO (1996) describe three stages in pest risk analysis. This document satisfies the requirements of FAO Stages 1 (initiation) and 2 (risk assessment) by considering each area of inquiry as a separate step.

1. Initiating Event: Proposed Action

This pest risk assessment is commodity-based or "pathway-initiated" because the USDA was requested to authorize importations of fresh common fig fruit *(Ficus carica)* from Mexico into the United States. This is a potential pathway for the introduction of plant pests on the figs. The authority to regulate fruit and vegetable importation is 7 CFR § 319.56.

2. Assessment of Weediness Potential

Figs are a widely cultivated crop and are not listed in any of the references as a weed, so the weediness screening for *Ficus carica* does not require a pest-initiated pest risk assessment (Table 1).

Table 1. Process for Determining Weediness Potential of Commodity

Commodity: *Ficus carica* (fig, common fig, edible fig); Family Moraceae

Phase 1: Fig, native to Southwestern Asia, is widely cultivated in tropical and temperate parts of the world, including the United States (especially in more mild climates).

Phase 2: Is the species listed in:

No	Geographical Atlas of World Weeds (Holm, *et al.,* 1979)
No	World's Worst Weeds (Holm, 1977)
No	Report of the Technical Committee to Evaluate Noxious Weeds for Federal Noxious Weed Act (Gunn & Ritchie, 1982)
No	Economically Important Foreign Weeds (Reed, 1977)
No	Weed Science Society of America list (WSSA, 1989)
No	Is there any literature reference indicating weediness? *e.g.,* AGRICOLA, CAB, Biological Abstracts, and AGRIS search on "species name" combined with "weed"

Phase 3: The species is widely prevalent in the United States and the answer to all of the questions is **No**, therefore this risk assessment continues.

3. Previous Risk Assessments, Current Status, and Pest Interceptions

Decision history for *Ficus carica* fruit:

1925—Mexico—deny entry because of fruit flies and other insects.
1991—Puerto Rico—deny entry—No approved USDA treatment for *Anastrepha* spp.
1990—USSR—deny entry—No acceptable treatment for *Ceratitis capitata*
1988—New Zealand—approved entry into all ports
1988—Italy—deny entry—No acceptable treatment for *Ceratitis capitata* or *Silba virescens*
1984—Japan (into Guam)—deny entry—No acceptable treatment for a complex of insects
1983—Chile—deny entry—No residue tolerance established for fumigation of figs for *Brevipalpus chilensis*
1969—Peru—deny entry—No approved treatment for *Ceratitis capitata*, *Anastrepha fraterculus* and *A. serpentina*
1968—Brazil—deny entry—No satisfactory treatment available against fruit flies
1936—India—deny entry
1936—South Africa—deny entry
1932—Belgium (hot house grown)—permit entry into North Atlantic Ports
1926—Italy—deny entry
1926—Chile—permit entry

Table 1a. Summary of Pest Interceptions on Carica spp. from Mexico

Pest	Year of Interception	Location of Interception
Aleurodicus sp.	1996	baggage
Aleuroglandulus subtilis	1989	baggage
Anastrepha sp.	1988, 1989, 1993, 1994	baggage, permit cargo
Anthostomella sp.	1988, 1994	permit cargo
Anurogryllus sp.	1986	permit cargo
Aphididae spp.	1987, 1997	baggage
Arctiidae spp.	1989, 1991, 1994	baggage, permit cargo
Ascochyta sp.	2000	permit cargo
Blapstinus sp.	1998, 1999	baggage
Cecidoymiidae spp.	1985, 1987	baggage
Ceratitis capitata	2000	baggage
Cicadellidae spp.	1985, 1992, 2000	baggage
Cladosporium sp.	1990	baggage
Coccidae spp.	1987	baggage
Cochiobolus sp.	1998	permit cargo
Colletotrichum sp.	1990, 1999	permit cargo
Contarinia sp.	1991	baggage
Corynespora sp.	1991	permit cargo
Crematogaster sp.	1985, 1994	baggage
Curvularia sp.	1987	permit cargo
Diaspidadia sp.	2000	baggage
Didymella sp.	1996	permit cargo
Erythroneura sp.	1991	baggage
Hemiberlesia sp.	2000	baggage
Hypothenemus sp.	2000	permit cargo
Jadera sp.	1993	permit cargo
Lacinipolia sp.	1987	permit cargo
Lepidoptera spp.	1985	baggage
Leptosphaeria sp.	1988, 1994	permit cargo
Limacodidae spp.	2000	permit cargo

Table 1a. Summary of Pest Interceptions on Carica spp. from Mexico

Metachroma sp.	1998	baggage
Microcentrum sp.	1985	permit cargo
Miridae spp.	1987	baggage
Myochrous sp.	1988	baggage
Noctuidae spp.	1987	baggage
Nymphalidae spp.	1991	baggage
Oiketicus sp.	1988	permit cargo
Ophiodothella sp.	1994	permit cargo
Paraleyrodes sp.	1986	baggage
Pentatomoidea spp.	1985	baggage
Periconia sp.	1987	permit cargo
Phoma sp.	1996	baggage
Phyllosticta	1999	permit cargo
Pseudaonidia trilobitiformis	1992	baggage
Pseudococcidae spp.	1985, 1994, 1996, 1999, 2001	baggage
Puto sp.	1994	baggage
Pyralidae spp.	1998	baggage
Pyraustinae spp.	1990,1997	baggage
Smicronyx sp.	1997	baggage
Stemphylium sp.	1987, 1995	permit cargo
Systena sp.	1996, 1999	baggage, miscellaneous
Tarsonemus sp.	1987	baggage
Tetraleurodes quadratus	1995	permit cargo
Tetraleurodes sp.	1997	baggage
Tettigoniidae spp.	1995	permit cargo
Tortricidae spp.	1986, 1999	baggage

For informational purposes only, the pest interceptions from 1985-2000 for *Ficus* spp. from other countries include:

Costa Rica *Anastrepha* sp. on *F. carica* fruit
Diaspididae sp. on *F. benjamina* leaf
Coccidae sp. on *Ficus* sp. leaf
Pseudococcidae sp. on *Ficus* sp. leaf

Honduras	Orthezia sp. on *Ficus* sp. leaf
Nicaragua	Olethreutinae sp. on *F. carica* (plant part not specified)
Argentina	*Anastrepha* sp. on *F. carica* fruit Tephritidae sp. on *F. carica* fruit *Ceratitis capitata* on *F. carica* fruit *Ceratitis capitata* on *Ficus* sp. fruit *Pseudococcus* sp. on *F. carica* fruit Coleoptera sp. on *F. carica* fruit Pentatomidae sp. on *F. carica* fruit
Brazil	*Orthezia praelonga* on *Ficus* sp. leaf
Columbia	*Anastrepha* sp. on *F. carica* and *Ficus* sp. fruit *Argyresthia* sp. on *F. carica* fruit Curculionidae sp. on *F. carica* fruit Diptera sp. on *F. carica* fruit
Ecuador	*Acrolophus* sp. on *F. carica* fruit Tortricidae sp. on *F. carica* fruit Diptera sp. on *Ficus* sp. fruit
Guyana	*Pseudaonidia trilobiformis* on *Ficus* sp. leaf
Peru	*Phoma* sp. on *F. carica* fruit *Pinnaspis* on *F. carica* fruit Pyralidae sp. on *Ficus* sp. fruit

4. Associated Pests

The pests associated with all plant parts of *Ficus carica* in Mexico are listed in Table 2. The relative distribution with the United States, quarantine status, and an assessment of the likelihood of that particular pest moving with the commodity during transport also is listed.

Table 2. Summary of pests associated with fig (Ficus carica) in Mexico and distribution within the United States on any host

Pest	Geographic Distribution[1]	Plant Part Affected[2]	Quarantine Pest	Follow Pathway	References
ARTHROPODS					
ACARI					
Tarsonemidae					
Tarsonemus sp.[4]	MX	L	Yes	No	PIN309, 2000
Tenuipalpidae					
Brevipalpus phoenicis (Geijskes)	MX, US	F, L, S	No	Yes	Jeppson, *et al.*, 1975
Tetranychidae					
Eotetranychus lewisi (McGregor)	MX, US	L	No	No	Tutle, *et al.*, 1976
Tetranychus cinnabarinus (Boisduval)	MX, US	L	No	No	Tovar, *et al.*, 1995
Tetranychus urticae Koch	MX, US	L	No	No	Tovar, *et al.*, 1995
COLEOPTERA					
Cerambycidae					
Ptychodes trilineatus L.	MX	S	Yes	No	Chemsak & Linsley, 1982; Martell, 1981
Chrysomelidae					
Metachroma sp.[4]	MX	F	Yes	Yes	PIN309, 2000
Myochrous sp.[4]	MX	F	Yes	Yes	PIN309, 2000
Lyctidae					
Lyctus planicollis LeConte	MX	S	No	No	Tovar, *et al.*, 1995[5]
Platypodidae					
Platypus parallelus F.	MX	S	No	No	Borror, *et al.*, 1989; Tovar, *et al.*, 1995[5]

Table 2. Summary of pests associated with fig (Ficus carica) in Mexico and distribution within the United States on any host

Scolytidae					
Xyleborus volvulus F.	MX	S	No	No	Borror, *et al.*, 1989; Tovar, *et al.*, 1995[5]
Tenebrionidae					
Blapstinus fuliginosus Casey	MX	F	No	Yes	Arnett, 1983
Blapstinus sp.[4]	MX	F	No	Yes	PIN309, 2000
Systena sp.[4]	MX	F	Yes	Yes	Arnett, 1983; PIN309, 2000
DIPTERA					
Tephritidae					
Anastrepha fraterculus Wiedemann	MX	F	Yes	Yes	Norrbom, *et al.*, 1988
Anastrepha ludens Loew	MX, US(TX)	F	Yes	Yes	EPPO; CPC, 1998
Anastrepha serpentina Wiedemann	MX	F	Yes	Yes	Norrbom, *et al.*, 1988
Ceratitis capitata Wiedemann	MX, US(HI)	F	Yes	Yes	PNKTO; CPC, 1998; White & Elson-Harris, 1992
HEMIPTERA					
Largidae					
Stenomacra marginella Martell	MX, US (CA, AZ)	I, F, L, S	No	No	Henry & Froeschner, 1988; Tovar, *et al.*, 1995[5]
HOMOPTERA					
Aleyrodidae					
Tetraleurodes sp.[4]	MX	L	Yes	No	PIN309, 2000
Aphididae					
Aphis craccivora Koch	MX, US	L	No	No	Blackman & Eastop, 1994
Aphis gossypii Glover	MX, US	L	No	No	Blackman & Eastop, 1994

Table 2. Summary of pests associated with fig (Ficus carica) in Mexico and distribution within the United States on any host

Toxoptera aurantii (B. de Fonscolombe)	MX, US	I, L, S	No	No	Krantz, *et al.*, 1977
Asterolecaniidae					
Asterolecanium pustulans Cockerell	MX, US	(F?), L, S	No	Yes	CIE, 1984
Coccidae					
Parasaissetia nigra Nietner	MX, US	L	No	No	EPPO, 1992
Pulvinaria sp.	MX	L, S	No	Yes	Tovar, *et al.*, 1995[5]
Saissetia coffeae (Walker)	MX, US	L, S	No	No	Krantz, *et al.*, 1977
Saissetia oleae (Olivier)	MX, US	L, S	No	No	Hill, 1983
Diaspididae					
Aonidiella citrina (Coquillet)	MX, US	F, L, S	No	Yes	EPPO, 1992
Chrysomphalus aonidum (L.)	MX, US	L	No	No	Krantz, *et al.*, 1977
Hemiberlesia sp.[4]	MX	F	No	Yes	PIN309, 2000
Pseudaonidia trilobitiformis (Green)	MX, US (FL, PR)	F, I, L, S	No	Yes	PIN309, 2000; Miller, 1985; Miller, 1997; Nakahara, 1982
Selenaspidus articulatus (Morgan)	MX, US	L	No	No	Krantz, *et al.*, 1977
Pseudococcidae					
Nipaecoccus nipae Maskell	MX, US	L	No	No	CPC, 1998
Planococcus citri (Risso)	MX, US	F, I, L	No	Yes	Krantz, *et al.*, 1977
Pseudococcus longispinus (Targioni-Tozzetti)	MX, US	F, L, S	No	Yes	Spiller & Wise, 1982
Puto sp.[4]	MX	F, L, S	Yes	Yes	PIN309, 2000
HYMENOPTERA					
Formicidae					
Crematogaster sp.[4]	MX	F	No	Yes	PIN309, 2000

Table 2. Summary of pests associated with fig (Ficus carica) in Mexico and distribution within the United States on any host

LEPIDOPTERA					
Pyralidae					
Azochis gripusalis Walker	MX	S	Yes	No	Zhang, 1994
Cadra figulilella Gregson	MX, US	F	No	Yes	Zhang, 1994
Sphingidae					
Pachylia syces Huber	MX	S	Yes	No	Zhang, 1994
THYSANOPTERA					
Phlaeothripidae					
Gynaikothrips ficorum Marchal	MX, US	L	No	No	CPC, 1998; Tovar, *et al.*, 1995[5]
BACTERIA					
Agrobacterium tumefaciens Conn. (Proteobacteria: Rhizobiales)	MX, US	R, S	No	No	CPC, 2000
FUNGI					
Oomycetes					
Phytopthora cinnamomi Rands [syn. *P. citrophthora* (Sm.& Sm.) Leonian]	MX, US	R	No	No	CPC, 2000; Farr, *et al.*, 1989
Phytophthora palmivora Butler	MX, US(AZ, CA, FL, HI)	F, R	No	Yes	Chessa, 1997; CPC, 2000; Farr, *et al.*,1989
Pythium ultimum Trow	MX, US	R	No	No	CPC, 2000
Ascomycetes					
Capnodium footi Berk.	MX, US	F, L	No	Yes	Alvarez, 1967; Farr, *et al.*, 1989
Ceratocystis paradoxa (Dade) C. Moreau	MX, US	R	No	No	Farr, *et al.*, 1989; Ogawa & English, 1991
Cochiobolus sp.[4]	MX	F	Yes	Yes	PIN309, 2000
Didymella sp.[4]	MX	F	Yes	Yes	PIN309, 2000
Gibberella fujikuroi (Sawada) Ito [teleomorph *Fusarium moniliforme* Sheldon]	MX, US	S	No	No	CPC, 2000; Farr, *et al.*, 1989; Ploetz, *et al.*, 1994

Table 2. Summary of pests associated with fig (Ficus carica) in Mexico and distribution within the United States on any host

Glomerella cingulata (Stoneman) Spauld. & H. Schrenk. [syn. *Colletotrichum gloeosporioides* Penz.]	MX, US	F, L	No	Yes	CPC, 2000; Farr, *et al.*, 1989; PIN309, 2000
Leptosphaeria sp.[4]	MX	F	Yes	Yes	PIN309, 2000
Rosellinia necatrix Prill [anamorph *Dermatophora necatrix* Hart]	MX, US	L, R, S	No	No	CPC, 2000
Stemphylium sp.[4] [anamorph *Pleomorpha* sp.]	MX	F	Yes	Yes	PIN309, 2000
Venturia sp.[4] [anamorph *Fusicladium* sp.]	MX	L	Yes	Yes	Alvarez, 1967
Deuteromycetes					
Alternaria sp.[3]	MX, US	F, L	No	Yes	Alvarez, 1967; Chessa, 1997; Farr, *et al.*, 1989
Ascochyta sp.[3, 4]	MX, US	F, L	Yes	Yes	Farr, *et al.*, 1989; PIN309, 2000
Cladosporium herbarum Link ex Fr.	MX, US	F, L	No	Yes	Chessa, 1997; Farr, *et al.*, 1989
Cladosporium sp.[4]	MX	F, L	Yes	Yes	Farr, *et al.*, 1989; PIN309, 2000
Cercospora bolleana Speg.	MX, US(HI)	L	Yes	No	Alvarez, 1967; Raabe, *et al.*, 1981
Penicillium sp.[4]	MX	F	Yes	Yes	Alvarez, 1967; Chessa, 1997; Farr, *et al.*, 1989
Phoma sp.[4]	MX	F	Yes	Yes	PIN309, 2000
Phyllosticta sp.[3, 4]	MX	L, F	Yes	Yes	Alvarez, 1967; Farr, *et al.*, 1989; PIN309, 2000
Phymatotrichopsis omnivora (Duggar) Hennebert. [syn. *Phymatotrichum omnivorum* (Shear) Dugg.][3]	MX, US(AZ, TX)	R	No	No	CPC, 2000; Farr, *et al.*, 1989

Table 2. Summary of pests associated with fig (Ficus carica) in Mexico and distribution within the United States on any host

Basidiomycetes					
Cerotelium fici (E.J. Butler) Arth.[3] [syn. *Uredo fici*]	MX, US	L	No	No	Alvarez, 1967; Farr, *et al.*, 1989; Lanham, *et al.*, 1927
Corticium salmonicolor Berk. & Br.[3]	MX, US	S	No	No	Alvarez, 1967; Farr, *et al.*, 1989
NEMATODES					
Aphlenchoididae					
Aphelenchoides besseyi Christie	MX, US	L, S	No	No	EPPO, 1992
Hoplolaimidae					
Helioctylenchus multicinctus (Cobb) Golden	MX, US	R	No	No	CPC, 2000
Longidoridae					
Longidorus sp.[4]	MX	R	Yes	No	CPC, 2000
Xiphinema americanum	MX, US	R	No	No	CPC, 2000
Xiphinema index Thorne & Allen	MX, US	R	No	No	Wyss, *et al.*, 1980
Rotylenchulidae					
Rotylenchus reniformis	MX, US	R	No	No	CPC, 2000
VIRUSES					
Fig Mosaic virus	MX, US(HI)	L, S	No	No	Raabe, *et al.*, 1981; Sutic, *et al.*, 1999

[1] AZ = Arizona, CA = California, FL = Florida, HI = Hawaii, MX = Mexico, TX = Texas, US = United States
[2] F = fruit, I = inflorescence, L = leaves, F = fruit, R = root, S = stem
[3] This pest is reported to occur on hosts other than Ficus carica within the United States (Farr, et al., 1989).
[4] Quarantine pests identified only to the generic level are not further analyzed in this risk assessment (see discussion below).
[5] Tovar, et al., 1995 lists this organism as a pest of Ficus spp.

5. Quarantine Pests That Are Likely To Follow the Pathway

The quarantine pests of *Ficus carica* that can reasonably be expected to follow the pathway via inclusion in commercial shipments are further analyzed in this assessment. Other plant pests listed in Table 2 that were not chosen for further scrutiny may be potentially detrimental to the

agricultural systems of the United States; however, there were a variety of reasons for not subjecting them to further analysis. First, the pest's primary association may be with plant parts other than the commodity. Secondly, the pests may not be associated with the commodity during transport or processing because of their inherent mobility and/or instinct to avoid light or human activity. Thirdly, the pests were intercepted as biological contaminants of the commodity during inspection by Plant Protection and Quarantine Officers and are not expected to be present with every shipment.

In addition, the biological hazard of organisms identified only to the generic level is not assessed. In this assessment, this applies to the following 17 organisms previously identified in Table 2: *Ascochyta* sp., *Blapstinus* sp., *Cladosporium* sp., *Cochiobolus* sp., *Crematogaster* sp., *Didymella* sp., *Hemiberlesia* sp., *Leptosphaeria* sp., *Metachroma* sp., *Myochrous* sp., *Phoma* sp., *Phyllosticta* sp., *Puto* sp., *Stemphylium* sp., *Systena* sp., *Tarsonemus* sp., *Tetraleurodes* sp.

Identification to only the generic level may merely indicate the limits of the current taxonomic knowledge or the quality of the specimen submitted for identification. By necessity, pest risk assessments focus on the organisms for which biological information is available. The lack of biological information on any given insect or pathogen should not be equated with low risk because the lack of identification at the specific level does not rule out the possibility that a highly dangerous pest or virulent pathogen was intercepted. Development of detailed assessments for known pests that inhabit a variety of niches on the parent species, such as the surfaces or interiors of bark, wood, or foliage, allow effective mitigation measures to eliminate the known organisms as well as similar but incompletely identified organisms that inhabit the same niche.

6. Economic Importance: The Consequences of Introduction

The undesirable consequences that may occur from the introduction of quarantine pests are assessed within this section. For each quarantine pest, the potential consequences of introduction are rated in five areas called "risk elements": climate-host interaction, host range, dispersal potential, economic impact, and environmental impact. These risk elements reflect the biologies, host ranges, and climatic/geographic distributions of the pests. For each risk element, pests are assigned a rating of low (1 point), medium (2 points), or high (3 points). A cumulative risk rating is then calculated by summing the values.

Information supporting each rating is provided for each of the four pests analyzed within this section. The four pests are *Anastrepha fraterculus*, *Anastrepha ludens*, *Anastrepha serpentina*, and *Ceratitis capitata*. The ratings for each risk element and the value for the consequences of introduction for each pest are in Table 3. The criteria used to determine the ratings is described in the guidelines *(Pathway-Initiated Pest Risk Assessments: Guidelines for Qualitative Assessments, Version 5.0* (USDA, 2000) or at *http://www.aphis.usda.gov/ppq/pra/commodity/.)* Information used by the expert panel to assign ratings for each pest is summarized below.

Anastrepha fraterculus. The *Anastrepha fraterculus* complex has two or more predominant types (Baker, 1944). The Mexican form is recognized as having a narrower host range than the South American form, and they are morphologically and genetically distinct (Steck, 1991).

The natural range of *Anastrepha fraterculus* (complex) includes much of South America northward through Mexico. In the United States, it was trapped in southern Texas (Hardiness Zone 9) but this fruit fly could establish in Zones 10 and 11 as well. In Mexico, this fruit fly attacks plants in at least seven plant families: Rubiaceae, Rosaceae, Myrtaceae, Anacardiaceae, Sapotaceae, Combretaceae, Euphorbiaceae (Hernandez-Ortiz, 1992). The lifecycle, from egg-laying until adult emergence, ranges from 33 to 57 days. The flies are active throughout the year and there may be six to seven generations per year. In Peru, up to 50 eggs may be laid in single fruit, depending on maturity and variety of host fruit. *Anastrepha* spp. can fly as far as 135 km (Fletcher, 1989); therefore, natural movement is an important means of spread. In international trade, the larvae can be transported in fruit for long distances. This pest lowers yield because in

medium-to-high infestations premature fruit drop occurs on many hosts. The pest lowers the value of the commodity by increasing the costs of production (including chemical controls for adults). The presence of *Anastrepha* spp. larvae is likely to lower the market value of the fruit (or make it totally unmarketable in severe cases) causing a loss of international and interstate markets. The demonstrated capacity of this fruit fly to infest a wide variety of hosts indicates that it has the potential to expand its known host range when introduced to new geographical areas (Fletcher, 1989; Stone, 1942; White & Elson-Harris, 1992). While current control measures may be sufficient to reduce or limit its spread within a cropping area, this fruit fly's ability to impact noncultivated species means that a reservoir population is likely to establish outside of an agroecosystem. If this happened, ongoing mitigation measures would be required to economically produce a crop.

Anastrepha ludens. The natural range for this fruit fly is Mexico, Central America, and the Rio Grande Valley of Texas (some populations migrate each fall and winter from Mexico into the Rio Grande Valley). It occurs in one climate zone in Texas and probably could establish in two more zones. In Mexico, this pest attacks hosts in seven plant families (Hernandez-Ortiz, 1992). The life cycle, from egg-laying until adult emergence, ranges from 33 to 63 days. The number of generations per year can range from 1 to over 12. A single female may produce several hundred eggs. *A. ludens* is believed to be capable of flying over 161 km, at least in a series of flights (PNKTO, 1982; CABI/EPPO, 1992). This pest lowers yield because medium-to-high infestations cause premature fruit drop in many host species. The pest lowers the value of the commodity by increasing the costs of chemical controls for adults. *A. ludens* larvae lower the market value of the fruit, and in severe cases, make the fruit completely unmarketable, causing the loss of international and interstate markets. This pest is polyphagous (attacking many genera in many host families including native and introduced host species in the natural range of the fly), so full extension of its host range upon introduction into a new geographic area is possible (Fletcher, 1989; Stone, 1942; White & Elson-Harris, 1992). Chemical or biological control programs could be needed. The flies harbor a wide variety of common soil- and water-inhabiting Enterobacteriaceae in their gut (Kuzina, 2001).

Anastrepha serpentina. This pest occurs abundantly in Mexico and most countries of Central and South America (south to Brazil). It reportedly occurred in southern Texas, "but seldom has been found since about 1959" (Foote, *et al*., 1993). It may establish in two or more climactic zones. In Mexico, this pest occurs on hosts in at least six plant families (Hernandez-Ortiz, 1992). The range of this pest is reported as about 40 plant species in 13 plant families (Norrbom and Kim, 1988). *Anastrepha* spp. can fly up to 135 km (Fletcher, 1989), so natural movement is an important means of spread. The larvae could also be transported for long distances in international trade. This pest lowers yield because medium-to-high infestations cause premature fruit drop in many host species. The pest lowers the value of the commodity by increasing the costs of chemical controls for adults, and larvae may make the fruit completely unmarketable, causing the loss of international and interstate markets. This pest is polyphagus, and it would be hard to predict what other hosts it would infest if introduced into a new geographical area. This pest may stimulate the need for chemical or biological control programs (Fletcher, 1989; Stone, 1942; White & Elson-Harris, 1992).

Ceratitis capitata. This pest is widely distributed in the world including Hawaii, most of Africa, the Mediterranean, much of Central and South America, and Australia. It was accidentally introduced and subsequently eradicated from Florida, California, and Texas several times. It probably could establish in three climactic zones (9, 10, and 11) although it generally does not survive subzero winter temperatures. *C. capitata* is highly polyphagous and attacks a very wide range of unrelated fruit crops including many deciduous and subtropical fruit trees. Hosts include peach, citrus, coffee berries, cocoa, mango, guava, *Prunus* spp., Solanum spp., and *Ficus* spp. The lifecycle takes about a month from egg to adult; there may be 8 to 10 generations per year. Larval-infested fruit can be transported great distances. There is evidence that *C. capitata* can fly at least 20 km (Fletcher, 1989). This pest lowers yield because infestations cause premature fruit drop in

many host species. The pest lowers the value of the commodity by increasing the costs of chemical controls, and larvae may make the fruit completely unmarketable, causing the loss of international and interstate markets. This insect appears to have limited potential to destabilize the ecosystem, reduce biodiversity, or eliminate endangered/threatened species (Fletcher, 1989; Hendrichs, *et al*., 1983; Metcalf, *et al*., 1962; White & Elson-Harris, 1992).

Table 3. Risk Element Ratings: Consequences of Introduction Values

Pest	Climate/ Host	Host Range	Dispersal	Economic	Environ-mental	Consequences of Introduction Value
Anastrepha fraterculus	medium (2)	high (3)	high (3)	high (3)	medium (2)	medium (13)
Anastrepha ludens	medium (2)	high (3)	high (3)	high (3)	medium (2)	medium (13)
Anastrepha serpentina	medium (2)	high (3)	high (3)	high (3)	medium (2)	medium (13)
Ceratitis capitata	high (3)	high (3)	high (3)	high (3)	medium (2)	medium (14)

7. Likelihood of Introduction

The likelihood of introduction for each pest is based on two separate components. First, the amount of the commodity likely to be imported (Risk Element #6) is supplied by the country of proposed export. Secondly, pest opportunity (Risk Element #7) is estimated using five biological features (subelements 1–5) as described in USDA, 2000. These ratings and the value for the Likelihood of Introduction are summarized in Table 4.

Table 4. Summary of Risk Element #6: Quantity Imported Annually, Risk Element #7: Pest Opportunity and the Value for the Likelihood of Introduction

Pest	Risk Element #6: Quantity imported annually	Risk Element #7: Pest Opportunity					Likelihood of Introduction Value
		Survives post-harvest treatment	Survives shipment	Not detected at the port of entry	Moved to a suitable habitat	Finds a suitable host	
Anastrepha fraterculus	medium (2)	high (3)	high (3)	high (3)	high (3)	high (3)	high (17)
Anastrepha ludens	medium (2)	high (3)	high (3)	high (3)	high (3)	high (3)	high (17)
Anastrepha serpentina	medium (2)	high (3)	high (3)	high (3)	high (3)	high (3)	high (17)
Ceratitis capitata	medium (2)	high (3)	high (3)	high (3)	high (3)	high (3)	high (17)

Subelements 1–5 are rated as a series of independent events that must all occur to have a pest outbreak; the ratings for each element do not affect the ratings for the other elements. The sum of the rating for Risk Element #6 and for each subelement of Risk Element #7: Pest Opportunity gives the value for the Likelihood of Introduction. This cumulative risk value is an indicator of the likelihood that a particular pest would be introduced.

8. Conclusion

The sum the values for the Consequences of Introduction and the Likelihood of Introduction produce the Pest Risk Potential value. This cumulative total expresses the risk on the following scale: Low = 11–18 points, Medium = 19–26 points, and High = 27–33 points. The results for the four pests are summarized in Table 5.

Table 5. Summary of the values for the Consequences of Introduction and the Likelihood of Introduction and the Pest Risk Potential

Pest	Consequences of Introduction Value	Likelihood of Introduction Value	Pest Risk Potential
Anastrepha fraterculus (Wiedemann)	Medium (13)	High (17)	High (30)
Anastrepha ludens (Loew)	Medium (13)	High (17)	High (30)
Anastrepha serpentina (Wiedemann)	Medium (13)	High (17)	High (30)
Ceratitis capitata (Wiedemann)	Medium (14)	High (17)	High (31)

Pests with an overall Pest Risk Potential value of Low typically do not require mitigation measures, while a value within the Medium range indicates that specific phytosanitary measures may be necessary. All the organisms within this risk assessment had analysis values within the High range for their Pest Risk Potential. The guidelines state that a High Pest Risk Potential means that specific phytosanitary measures are strongly recommended and that port-of-entry inspection is not considered sufficient to provide phytosanitary security. The choice of appropriate measures to mitigate risks is part of Risk Management within APHIS and is not addressed within this risk assessment document.

C. References

Alvarez, M.G. 1967. Enfermedades de las plantas en la Republic Mexicana. Editorial Limusa-Wiley, S.A., MX.

Arnett, R. H., Jr. 1983. Tenebrionidae. Checklist of the beetles of North and Central America and the West Indies. Flora and Fauna Publications, Gainesville, FL.

Baker, A.C., Stone, W.E., Plummer, C.C. and M. McPhail. 1944. A review of studies on the Mexican fruitfly and related Mexican species. USDA Misc. Publ. 531 Washington, DC. 155 pp.

Blackman, R.L. and V.F. Eastop. 1984. Aphids on the world's crops. An identification guide. Wiley and Sons., Chichester, UK.

Borror, D.J., Triplehorn, C.A. and N.F. Johnson. 1989. An introduction to the study of insects. Holt, Rinehart and Winston, Inc. Orlando, FL. 875 pp.

Chemsak, J.A. and E.G. Linsley (eds). 1982. Cerambycidae and Disteniidae: Checklist of the beetles of North America, Central America, and the West Indies, Vol. 7. Plexus Publishing. Medford, NJ.

Chessa, I. 1997. Fig. *In*: Postharvest physiology and storage of tropical and subtropical fruits. CAB Int'l, Wallingford, UK. p. 245–268.

CIE. 1984. Distribution maps of pests, Map No. 460, *Asterolecanium pustulans*. CAB Int'l., Wallingford, UK.

CPC. 1998. Crop Protection Compendium. CAB Int'l., Wallingford, UK.

EPPO. 1992. Quarantine pests for the European communities and for the European and Mediterranean Plant Protection Organization. CAB Int'l., Wallingford, UK.

FAO. 1996. International standards for phytosanitary measures. Section 1—Import regulations: Guidelines for pest risk analysis. Secretariat of the Int'l. Plant Protec. Convention, United Nations—FAO, Rome, IT.

FAO. 1999. Glossary of phytosanitary terms. Int'l Standards Phytosanitary Measures No. 2, Secretariat of the Int'l Plant Protec. Convention, United Nations—FAO, Rome, IT.

Farr, D. F., Bills, G. F., Chamuris, G. P. and A. Y. Rossman. 1989. Fungi on plants and plant products in the United States. Amer. Phytopathol. Soc., St. Paul, MN.

Fletcher, B.S. 1989. Ecology; movements of tephritid fruit flies. *In:* World Crop Pests 3(B). Fruit flies; their biology, natural enemies and control. Robinson, S.S. and G. Hooper (Eds.) Elsevier, NL.

Foote, R.H., Blanc, F.L and A.L. Norrbom. 1993. Handbook of the Fruit Flies (Diptera: Tephritidae) of America North of Mexico. Ithaca, NY.

Hendrichs, J., Ortiz, G., Liedo, P. and A. Schwarz. 1983. Six years of successful medfly program in Mexico and Guatemala. p. 353–365 *In*: Cavalloro, R. (Ed). Fruit Flies of Economic Importance. A.A. Balkema, Rotterdam, NL.

Henry, T.J. and R.C. Froeschner. 1988. Catalog of the Heteroptera or true bugs of Canada and the continental United States. E.J. Brill, NY. 958 pp.

Hernandez-Ortiz, V. 1992. El genero *Anastrepha Mexico*. Taxonomia, distribution y sus plantas huespedes. Instituto de Ecologia, Xalapa, MX.

Hill, D.S. 1983. Agricultural insect pests of the tropics and their control. 2nd ed. Cambridge Univ. Press. Cambridge, UK. 746 pp.

Holm, L.G., Plucknett, D. L., Pancho, J. V. and J.P. Herberger. 1977. World's worst weeds. Univ. Hawaii Press, Honolulu, HW.

Holm, L.G., Pancho, J. V., Herberger, J. P. and D.L. Plucknett. 1979. Geographical atlas of the world's weeds. John Wiley and Sons, NY.

Hopper, B.E. 1996. North American plant protection organization compendium of phytosanitary terms. Doc. No. 96–027. NAPPO Secretariat, Ottawa, CA.

Jeppson, L.R., Keifer, H.H. and E.W. Baker. 1975. Mites injurious to economic plants. Univ. Calif. Press, Berkeley, CA.

Kranz, J., Schutterer, H. and W. Koch. 1977. Diseases, pests, and weeds in tropical crops. John Wiley and Sons, Chichester, UK.

Kuzina, L., Peloquin, J.J., Vacek, D.C. and T.A. Miller. 2001. Isolation and identification of bacteria associated with adult laboratory Mexican fruit flies, *Anastrepha ludens* (Dipter: Tephritidae). Current Microbiol. 42: 290–294.

Lanham, W.B., Wyche, R.H. and R.H. Stansel. 1927. Spraying for the control of fig rust. TX Agric. Exp. Sta. Circ. No 47. 8 pp.

Malavasi, A. and R.A. Zucchi (Eds). 2000. Moscas-das-frutas de importancia economica no Brasil. Ribeirao Preto: Holos Editoria Ltda-ME. 327 pp.

Martell, C.G. 1981. Lista de insectos y acaros perjudiciales a los cultivos en Mexico. 2 Ed. Secretaria de Agricultura y Recursos Hidraulicos, Direccion General de Sanidad Vegetal. Mexico City, MX.

Metcalf, C.L., Flint, W.P. and R.L. Metcalf. 1962. Destructive and useful insects: Their habits and control, 4 Ed. McGraw-Hill, NY.

Miller, D. 1985. Pest risk assessment of armored scales on certain fruit. USDA memorandum (*unpublished)*.

Miller, C. 1997. Hazard identification analysis, evaluation of San Juan predeparture interceptions in baggage 1994–96. (*http://www.aphis.usda.gov/ppq/pra/commodity/hazardsanjuan* [September 10 2001]).

Nakahara, S. 1982. Checklist of the armored scales of the coterminous United States. USDA-APHIS-PPQ [handbook].

Norrbom, A.L. and K.C. Kim. 1988. A list of reported host plants of the species of *Anastrepha* (Diptera: Tephritidae). USDA-APHIS-PPQ, pp. 81–52.

Ogawa, J.M. and H. English. 1991. Diseases of temperate zone tree, fruit, and nut crops. Univ. Calif. Divis. Agric. Nat. Res., No. 3345, Oakland, CA.

PIN309. 2001. Port Information Network. USDA-APHIS, Riverdale, MD.

Ploetz, R. C., Zentmyer, G. A., Nishijima, W. T., Rohrback K. G. and H. D. Ohr (Eds). 1994. Compendium of tropical fruit diseases. Amer. Phytopathol. Soc., St. Paul, MN.

PNKTO. 1983. Data sheets on quarantine organisms No. 41: Trypetidae (non-European). OEPP/EPPO Bull. 13 (1).

Raabe, R.D., Conners, I.L and A.P. Martinez. 1981. Checklist of plant diseases in Hawaii. Hawaiian Inst. Tropical Agric. Human Resources. Info. Text Ser. 022. 313 pp.

Reed, C.F. 1977. Economically important foreign weeds. Agric. Handbk. No. 498.

Spiller, D.M and K. A. Wise. 1982. Catalogue (1860–1960) of New Zealand insects and their host plants. D.S.I.R. Bull. 231, Science Info. Divis., Wellington, NZ.

Stone, A. 1942. The fruitflies of the genus *Anastrepha*. USDA Misc. Publ. 439. Washington, DC. 112 pp.

Sutic, D.D., Ford, R.E. and M.T. Tosic. 1999. Plant virus diseases. CRC, Boca Raton, FL.

Tovar, D.C., Montiel, J.T.M., Bolanos, R.C., Yates, H.O., III, and J.F. Lara. 1995. Forest insects of Mexico. Universidad Autonoma Chapingo, Chapingo, MX. Publ. No. 6.

Tutle, D.M., Baker, E.W. and M.J. Abbatiello. 1976. Spider mites of Mexico (Acari: Tetranychidae). Int'l. J. Acarol. 2(2): 1–102.

USDA. 1990. Plant hardiness zone map. USDA-ARS Misc. Publ. No. 1475. Washington, DC.

USDA. 2000. Guidelines for pathway-initiated pest risk assessments (version 5.02). USDA-APHIS-PPQ, Riverdale, MD.

White, I.M. and M.M. Elson-Harris. 1992. Fruit flies of economic significance: Their identification and bionomics. CAB Int'l., Wallingford, UK.

Wilcox, J.A. 1975. Checklist of the beetles of North and Central America and the West Indies. Flora and Fauna Publications, Gainesville, FL.

WSSA. 1989. Composite List of Weeds. Weed Science Society of America.

Wyss, U., Lehmann, H. and R. Jank-Ladwig. 1980. Ultrastructure of modified root-tip cells in *Ficus carica*, induced by the ectoparasitic nematode *Xiphinema index*. J. Cell Sci. 41: 193–208.

Zhang, B. C. 1994. Index of economically important Lepidoptera. CAB Int'l., Wallingford, UK.

D. Preparers

Prepared by:
Michael J. Kenney, Plant Pathology

Revised September 10, 2001 by:
Michael K. Hennessey, Entomology
Eileen Sutker, Plant Pathology